CLAIMS

1. A magnetic field sensor for sensing an applied magnetic field, the sensor comprising:

a layer of magnetostrictive material having a magnetization vector that responds to the applied magnetic field by rotating in a plane and generating a stress;

a layer of electroactive material, mechanically bonded to the layer of magnetostrictive material, that responds to the stress by generating a voltage; and

electrodes that measure the voltage generated by the electroactive material in a direction substantially parallel to the plane in which the magnetization vector rotates.

2. The sensor of claim 1 wherein the magnetostrictive material is selected from the group consisting of amorphous-FeBSi, FeCoBSi alloys, polycrystalline nickel, iron-nickel alloys, iron-cobalt alloys and Terfenol-D®.

3. The sensor of claim 2 wherein the magnetostrictive material is selected from the group consisting of $Fe_xB_ySi_{1-x-y}$, where $70 < x < 86$ at%, $2 < y < 20$, and $0 < z=1-x-y < 8$ at%, $Fe_xCo_yB_zSi_{1-x-y-z}$ where $70 < x+y < 86$ at% and y is between 1 and 46 at%, $2 < z < 18$, and $0 < 1-x-y-z < 16$ at%, polycrystalline nickel, iron-nickel alloys where Ni is between 40 and 70 at%, iron-cobalt alloys where Co between 30 and 80%, and Terfenol-D® $Fe_2(Dy_{0.67}Tb_{0.33})$.

4. The sensor of claim 2 wherein the magnetostrictive material comprises a composition near $Fe_{78}B_{20}Si_2$.

5. The sensor of claim 2 wherein the magnetostrictive material comprises a composition near $Fe_{68}Co_{10}B_{18}Si_4$.

6. The sensor of claim 2 wherein the magnetostrictive material comprises an iron-nickel alloy with substantially 50% Ni.

7. The sensor of claim 2 wherein the magnetostrictive material comprises an iron-cobalt alloy with substantially 55% Co.

8. The sensor of claim 1 wherein the electroactive material is selected from the group consisting of lead zirconate titanate ceramics ($Pb(Zr_xTi_{1-x})O_{3)}$, polyvinylidene difluoride polarized polymers (PVDF), aluminum nitride (AlN), quartz (SiO_x), ferroelectric materials, electrostrictive materials and relaxor ferroelectric materials.

9. The sensor of claim 8 wherein the electroactive material is electrostrictive material substantial of the form $(Bi_{0.5}Na_{0.5})_{1-x}Ba_xZr_yTi_{1-y}O_3)$.

10. The sensor of claim 8 wherein the electroactive material is a relaxor ferroelectric material substantially of the form $Pb(Mg_{1/3}Nb_{2/3})_3O_3)$.

11. The sensor of claim 1 wherein the magnetostrictive layer is bonded to the electroactive layer with non-conductive glue.

12. The sensor of claim 11 wherein the glue is non-conductive epoxy.

13. The sensor of claim 1 wherein the electroactive layer is a rectangular prism having thickness, *t*, width, *w*, and length, *l*, with $t \leq w \leq l$ and three pairs of opposing faces and wherein the electrodes are on one pair of opposing faces

and the magnetostrictive layer and a second magnetostrictive layer are bonded to another pair of opposing faces.

14. The sensor of claim 13 wherein a third and a fourth magnetostrictive layers are bonded to the third pair of opposing faces.

15. The sensor of claim 14 wherein the magnetostrictive layer is a continuous piece wrapped around and bonded to two pairs of opposing sides and the electrodes are on a third pair of opposing sides.

16. The sensor of claim 1 wherein the magnetostrictive layer is disk-shaped

17. The sensor of claim 1, wherein the electroactive layer is a cylinder with two circular faces and a side wall, the magnetostrictive layer is bonded to at least one circular face and electrodes are on the side wall in an opposing relationship.

18. The sensor of claim 17 wherein the side wall has a circumference and wherein the electrodes are arc-shaped, each electrode having an arc length of at least 1/8 and not greater than 3/8 of the circumference of the side wall.

19. The sensor of claim 1 wherein the electroactive layer is a cylinder of thickness, t, and diameter, d, and wherein $t \geq d$.

20. The sensor of claim 1 wherein the electroactive layer is a cylinder with two circular faces of diameter d and a side wall of height h wherein $h \geq d$ and wherein the electrodes are on the circular faces and the magnetostrictive layer is bonded to the side wall.

21. The sensor of claim 1, wherein the electroactive layer forms a hollow cylinder of length l, thickness t, and diameter, d where $t < d/2$ and $t \leq l$ and a pair of opposing end faces.

22. The sensor of claim 21 wherein the electrodes are applied to an inner cylinder surface and an outer cylinder surface.

23. The sensor of claim 22 wherein the magnetostrictive layer comprises a cylinder of magnetostrictive material inserted into the hollow cylinder of electroactive material.

24. The sensor of claim 21 wherein the electrodes are applied to the opposing end faces.

25. The sensor of claim 21 wherein the magnetostrictive material layer comprises a single piece of magnetostrictive material wrapped over, and bonded to, an outer surface of the cylinder.

26. The sensor of claim 21 wherein the magnetostrictive material layer comprises a single piece of magnetostrictive material wrapped over, and bonded to, an inner surface of the cylinder.

27. A magnetic field sensor for sensing an external magnetic field, the sensor comprising:

a layer of magnetostrictive material having a magnetization vector that responds to the applied magnetic field by rotating in a plane and generating a stress;

a layer of electroactive material mechanically bonded to the layer of magnetostrictive material that responds to the stress by generating a voltage; and

means for measuring the voltage generated by the electroactive material in a direction substantially parallel to the plane in which the magnetization vector rotates.

28. The sensor of claim 27 wherein the electroactive layer is a rectangular prism having thickness, t, width, w, and length, l, with $t \leq w \leq l$ and three pairs of opposing faces and wherein the electrodes are on one pair of opposing faces and the magnetostrictive layer and a second magnetostrictive layer are bonded to another pair of opposing faces.

29. The sensor of claim 27 wherein the magnetostrictive layer forms a hollow cylinder with an axis and a surface and the magnetostrictive layer has a magnetization vector that changes orientation from circumferential to axial on the surface of the cylinder in response to an external magnetic field applied in a direction parallel to the axis.

30. The sensor of claim 27 wherein the electroactive layer forms a hollow cylinder with an axis and a surface and wherein the magnetostrictive layer is wrapped around and bonded to the surface and has a magnetization vector that changes orientation from circumferential to axial on the surface of the cylinder in response to an external magnetic field applied in a direction parallel to the axis.

31. The sensor of claim 30 further comprising a second magnetostrictive layer bonded to an inner surface of the hollow cylinder, wherein the second magnetostrictive layer has a magnetization vector that changes orientation from circumferential to axial on the surface of the cylinder in response to an external magnetic field applied in a direction parallel to the axis.

32. A method for fabricating a magnetic field sensor for sensing an applied magnetic field, the method comprising:

(a) forming a layer of magnetostrictive material having a magnetization vector that responds to the applied magnetic field by rotating in a plane and generating a stress;

(b) forming a layer of electroactive material with electrodes that measure the voltage generated by the electroactive material;

(c) mechanically bonding the layer of magnetostrictive material to the layer of electroactive material so that the electroactive material responds to the stress by generating a voltage and the voltage generated by the electroactive material is measured in a direction substantially parallel to the plane in which the magnetization vector rotates.

33. The method of claim 32 wherein step (a) comprises:

(a1) heat treating the magnetic material in the absence of an external magnetic field to relieve stress.

34. The method of claim 32 wherein step (a) comprises:

(a1) heat treating the magnetic material in the presence of an external magnetic field to relieve stress and to induce a preferred direction of quiescent magnetization after heat treatment.

35. The method of claim 32 wherein step (b) comprises:

(b1) applying a saturating electrical voltage to electrodes in order to polarize the electroactive material.

36. The method of claim 32 further comprising:

(d) applying a saturating voltage to the electrodes in order to polarize the electroactive material

37. The method of claim 32 further comprising:

(d) heat treating the sensor to relieve stress in the magnetic material.

38. The method of claim 37 wherein step (d) comprises

(d1) applying a magnetic field during the heat treatment to induce a preferred quiescent magnetization direction.

39. The method of claim 32 wherein step (a) comprises selecting the magnetostrictive material from the group consisting of amorphous FeBSi, nickel, iron-nickel alloys, iron-cobalt alloys and Terfenol-D®.

40. The method of claim 32 wherein step (b) comprises selecting the electroactive material from the group consisting of lead zirconate titanate ceramics, polyvinylidene fluoride polarized polymers, aluminum nitride, quartz SiO_x, ferroelectric materials, electrostrictive materials and relaxor ferroelectric materials.

41. The method of claim 32 wherein step (c) comprises bonding the magnetostrictive layer to the electroactive layer with glue.

42. The method of claim 41 wherein the glue is a non-conductive epoxy.